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ECONOMIC PLANT DISEASES COMMON IN KANSAS AND THEIR CONTROL[1]

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NATURE OF PLANT DISEASES

Plant diseases are caused chiefly by the presence of fungi and bacteria in plant tissues. In some instances no organism has been discovered as the causal factor. The annual loss from the diseases in Kansas attacking economic plants aggregates many millions of dollars. Some diseases may be almost entirely prevented by practicing control measures, some may be partially controlled, while a few are of a nature for which a practical means of control is not known at the present time.

Most of the plant diseases are the result of abnormal conditions in plants brought about by (1) a fungous infection, (2) a bacterial infection, (3) a weakened condition in a plant, not the result of an organism but caused by environmental factors or by a virus.

A fungus is a plant which is not able to manufacture its own food. It obtains its nourishment on or within the tissues of higher,

1. Contribution No. 229 from the Department of Botany.

green plants, either living or dead. The fungi cause leaf spots, blights, cankers, rots, rusts, smuts, etc., on our garden, forest, and field crops. These are called fungous diseases when evidences of the fungi can be detected. This often requires microscopic examination.

Bacteria are also microscopic plants commonly spoken of as "germs," which in many cases produce plant diseases. The general symptoms of plant diseases caused by bacteria are not greatly different from fungous diseases. Apple and pear blight, black chaff of wheat, and blackleg of potato are examples of bacterial diseases commonly found in Kansas. The invasion of plant tissues by the proper species of bacteria may cause soft rots, blights, cankers, spots, etc., in the host plant.

Nonparasitic or "physiological" diseases are, as the name signifies, not brought about by organisms. They constitute a large group of plant diseases which are among the most difficult to control. Some are the result of a combination of soil and climatic conditions which interfere with the proper growth and development of the plant or crop.

A group of degeneration diseases, commonly spoken of as virus troubles, are not uncommon and are causing great damage. The mosaic diseases of tomato and potato are very common examples. Spindle tuber of potato is a virus disease that is very serious and is responsible for cutting down yields. Virus diseases are not caused by any known organism, although they are transmissible.

It generally becomes necessary to learn the cause of a plant disease before satisfactory remedial measures may be advised. In the pages which follow, a short description of the most striking symptoms of the common economic plant diseases occurring in Kansas is given. Recommendations for their control accompany each description where remedial measures are known.

No attempt has been made to enumerate all fungi or bacteria known to cause plant diseases. Only those plant diseases which are most frequently found and which cause damage are mentioned. In several instances it is suggested that the reader write to the Kansas Agricultural Experiment Station for specific information.

A full discussion of the corrosive sublimate, hot formaldehyde, and copper carbonate treatments for seed disinfection and of the preparation of Bordeaux mixture and lime sulphur is included.

When in doubt concerning the identification of a plant disease,

send in material for identification. In submitting plant disease material, kindly observe the following suggestions:

1. Always send plenty of material. Proper identification is often impossible if only a single leaf or a fragment of bark is sent. Samples of small plants should include root, stems, and leaves.

2. Wrap soft plants first in newspaper and then in oil paper if convenient. Do not crowd material into an envelope or press it. Send samples as soon after collection as possible.

3. Woody tissue, such as limbs of trees, bark, or any hard wood should be carefully wrapped so that it will carry through the mail or express. It is necessary not only to send the diseased tissue, but some of the adjoining healthy tissue.

Special Note.—By communicating with the county agricultural agent, or by writing to the Department of Botany of the Agricultural Experiment Station, Manhattan, Kan., franked mailing tags may be obtained which will carry plant disease specimens free of postage.

PLANT DISEASES AND THEIR CONTROL

CROP.	Disease.	Symptoms.	Control or prevention.
ALFALFA	Leaf spots	There are several different fungous leaf spots. Leaves turn yellow, brown, dry up, and fall off.	Where practical cut crop before foliage drops too much, otherwise loss of hay results.
	Violet root rot	Plants die out in spots. Violet-red fungus can be noticed on roots, which break off easily.	Old alfalfa fields should be plowed up and not put back in alfalfa for at least three years.
	Root rots	Some new root rots occur in Kansas. Plants die and the stand becomes poor.	Plow badly diseased fields, and where possible do not replant to alfalfa for several years. Write the Agricultural Experiment Station for information.
	Wilt	Plants wilt, turn gray, white or brown, and die during the growing season. The stand becomes thin. Noticeable in fields three years old or older. When the bark is removed from diseased roots, the color is yellow or brown.	Plow badly diseased fields. When possible do not replant to alfalfa for a few years. Write the Agricultural Experiment Station for further information.
APPLE (*a*)	Black rot	Soft, brown rot of part or entire apple. Brown leaf spots. Cankers on limbs. Not common in Kansas.	The sprays recommended for blotch should control this disease. Control of codling moth.
	Blister, or Illinois canker	Death of large limbs or entire tree. Definite cankers show blister-like or "nail head" fungous bodies. Ben Davis most susceptible.	Badly diseased trees should be removed and burned. Keep disease out of young orchard by proper pruning and painting wounds. Remove all diseased limbs and burn.
	Blotch	Brown, jagged spots on skin of fruit, scaly bark on twigs and limbs, and very small white or tan spots on leaves.	Spray with Bordeaux mixture (3-4-50). Follow the apple spray schedule advised for your section of the state.
	Crown gall	Knots or galls on the crowns and roots of trees. Usually produces an abundance of fibrous roots.	Trees affected are never very thrifty. See that trees do not have crown gall when set.
	Fire blight, twig blight, etc.	The leaves, twigs, blossoms turn brown, black and dry. Cankers on limbs and trunks occur.	Do not plant pear trees in apple orchards. Remove those near apple trees. Write the Agricultural Experiment Station for further control measures.

PLANT DISEASES AND THEIR CONTROL—CONTINUED.

CROP.	Disease.	Symptoms.	Control or prevention.
APPLE (*a*)—*Concluded.*	Rust	Yellowish leaf spots on leaves. Does not generally seriously attack fruit in Kansas. Spreads from red cedar trees.	The fungicidal sprays advised for scab and blotch will not generally control apple rust in Kansas. Do not advise cutting down cedar trees. Do not plant cedar trees for windbreaks near apple orchards. Plant resistant varieties.
	Scab	Small scaly, dark greenish spots on fruit and dark olive green spots on both sides of leaves.	Spray with lime-sulphur, 1½ gallons to 50 gallons water before blossoms show pink. (*b*) Spray again the same as above when petals are from one-half to two-thirds fallen. Other sprays given for blotch later in season help to control scab. Apples which have late scab infections will not keep in storage, but will start decay.
ASPARAGUS	Rust	Black lesions on the leaf stalks late in season.	There are commercial varieties on the market which are resistant. Grow one of these.
BARLEY	Covered smut	Heads turn into a black mass of smut spores, the mass held together by thin gray membrane.	Use long-time formaldehyde treatment, 1 pint to 40 gallons water, soaking seed for 2 hours. Plant as soon as possible. Treating the seed with Uspulun is also satisfactory.
	Loose smut	Heads turn into a loose, black mass of smut spores, which are soon blown away, leaving naked rachis.	The long-time formaldehyde treatment is partially effective; same as for covered smut. Complete control is difficult.
	Stripe disease	Not common in Kansas. Causes brown stripes on leaves, weakens stems; and heads shrivel.	Soak seed 30 minutes in formaldehyde, 1 pint to 30 gallons water or give long-time formaldehyde treatment.
BEAN	Anthracnose	Reddish-brown spots, partially sunken on pods and stems of seedlings. The leaves frequently have red spots on the veins.	Use disease-free seed. Do not work among plants while they are wet. Bordeaux 4-5-50 at frequent intervals will help. Grow resistant varieties where practical.
	Bacterial blight	Leaves become spotted. Diseased areas fall out, leaf becomes shredded. Pods become swollen and ulcer-like.	Disease carried on seed. Avoid getting seed that is diseased. The best seed comes from arid regions. Write the Agricultural Experiment Station for the names of resistant varieties.

PLANT DISEASES AND THEIR CONTROL—CONTINUED.

CROP.	Disease.	Symptoms.	Control or prevention.
BEAN—*Concluded.*	Mosaic	Leaves become mottled light green or yellowish, warp or curl. Plants are stunted and produce few pods.	Secure seed from disease-free stock or select your own seed from healthy plants.
	Rust	Small reddish-brown pustules on the leaves. May cause leaves to drop from plants.	Not serious in Kansas. Destroy refuse and rotate crops if necessary. Varieties vary in resistance. Write for information.
BEET	Leaf spot	Reddish brown spots on leaves of red and sugar beets.	Generally not serious enough on garden red beet to warrant spraying. Write the Agricultural Experiment Station for instructions concerning treatment for sugar beets.
BLACKBERRY	Anthracnose	Gray scaly spots on canes and small leaf spots on foliage. Canes frequently split open.	Use 2½ gallons lime sulphur to 50 gallons of water, together with one pound of glue if convenient. Sprays should be applied before blossom buds open and again two weeks later, using 1½ gallons lime sulphur to 50 of water. Repeat if necessary.
	Cane blight	Fruit spurs dry up and fruit does not ripen. Often attributed to dry weather.	Remove all dead and sickly canes as they appear. Irrigate where possible. A difficult disease to control. Plants may recover naturally.
	Crown gall	Swellings occur on crown, roots and canes, similar to that of apple.	No control except to dig up and burn. Set no plants showing galls of any kind.
	Rust	Orange-yellow pustules on leaves and young canes.	Remove diseased plants as soon as noticed, taking care to remove all the roots. *Burn all refuse immediately.* Sprays of no value. Plant resistant varieties such as Snyder.
	Septoria leaf spot	Light-brown to dark-brown spots on leaves and canes.	Spray with lime-sulphur 1-50 or Bordeaux 4-4-50 shortly after leaf buds unfold. If necessary spray again two weeks later.
CABBAGE, TURNIP, RAPE, CAULIFLOWER.	Black rot	Heads small, decay follows, producing bad odor. Veins and mid-ribs become black. Not common in Kansas.	Use disease-free seed. Rotate crops for 3 or 4 years. Disinfect seed. Burn rotted plants. Do not allow wild mustard to grow in cabbage fields. Control insects.

CROP.	Disease.	Symptoms.	Control or prevention.
CABBAGE, ETC.—*Concluded.*	Wilt or yellows	Young plants turn yellow and die. Leaves fall off from older plants, leaving bare stalks and small heads.	Rotate crops for 4 or 5 years. Do not throw diseased plants on manure pile. Write to the Agricultural Experiment Station for names of resistant varieties.
CANTALOUPE, MUSKMELON, CUCUMBER (*c*).	Anthracnose	See watermelon	See watermelon.
	Bacterial wilt	Plants wilt and die especially in the seedling stage. Muskmelons and cucumbers are most susceptible.	Cover plants with screen cages until they begin to run, if only a few hills are grown. Keep plants free from insects. (They transmit and spread this disease.) Use Bordeaux 4-5-50 plus 2 pounds of lead arsenate powder at frequent intervals. Spray the under as well as the upper side of leaves. Planting rows of squash as trap crops a few days in advance of melon crop will help to attract bugs, thereby allowing melons to escape attack.
	Mosaic	Yellow mottling of leaves and fruit. "White pickles" with warty growths in case of cucumbers.	Occurs in field and greenhouse. Control plant lice. Keep down such weeds as nightshade and perennial ground cherry.
CELERY	Early blight	Leaf spots on young plants which cause leaves to dry.	Use only healthy plants for transplanting. Spray with Bordeaux mixture 5-5-50 when plants are set out and at 7 to 10 day intervals, depending upon weather and necessity.
	Late blight	Leaf spots in field and rot in storage. Both leaves and stalks are attacked.	Sprays as for early blight.
CHERRY	Brown rot	Cherries turn brown and rot. Gray or brown moldy fungus appears.	Follow the spray schedule advised by the Agricultural Experiment Station.
	Cherry knot	See plum diseases	See plum.
	Crown gall	See apple diseases	See apple.
	Leaf spot or shot hole	Small, brown spots which turn leaves yellow. Leaves fall from tree.	Spray with lime sulphur as for brown rot when petals have fallen. Other sprays same as for brown rot if disease persists.

PLANT DISEASES AND THEIR CONTROL—CONTINUED.

CROP.	Disease.	Symptoms.	Control or prevention.
CHERRY—*Concluded.*	Powdery mildew	The leaves become covered with a white fungous growth which looks like flour. Leaves curl slightly. Not a serious disease.	The ordinary sprays used for leaf spot and brown rot will control this.
CORN	Root, ear, stalk rot	Plants die very early or later in season, due to weakness of plant. Plants may fire, elbow, or break over due to weak stalk.	Good seed cannot be told by looking at it. Germination tests alone can tell. Plant seed from ears that show high germination, vigor and as free from molds as possible. Practice a reasonable rotation.
	Smut	Black masses or smut boils on ears, sheaths, tassels.	Seed treatment of no value. Rotate crops, not planting corn more often than once in three years. This will not eliminate smut, but will reduce it.
COWPEAS	Leaf spots	Leaves have small reddish-brown spots. Most common when plants are half grown.	No special treatment is necessary, as the plants generally outgrow the trouble.
CURRANT	Leaf spots	Spots on leaves, which turn yellow, eventually dry and fall off.	Bordeaux sprays 3-4-50 as soon as noticed will hold this disease in check. Spray several times.
GRAPE	Black rot	Grapes turn brown, dry up before they are ripe. Leaves become spotted.	Spray with Bordeaux 5-5-50, (1) when buds are opening, (2) when the first few leaves show, (3) when blossoms have fallen, and (4) at two-week intervals until ripe. (Rarely need full schedule in Kansas.)
	Downy mildew	Yellowish spots on upper part of leaf, from ¼ to ½ inch in size. Cottony white growth on the lower surface. Does not attack fruit in Kansas.	Bordeaux sprays, same as for black rot, will control this disease.
LETTUCE	Drop	Most commonly found in greenhouse. Lower leaves become limp, rotten, and plant dies. Not very common in Kansas.	Remove and destroy plants. Soil must be sterilized by steam or formaldehyde. Write to the Agricultural Experiment Station for details.
	Nematode or eel-worm	See tomato	See tomato.
	Root rots	Plants remain stunted, sickly color, and stop growing; common in greenhouse.	Proper soil and growing conditions are lacking. Drainage oftentimes is not satisfactory.

PLANT DISEASES AND THEIR CONTROL—CONTINUED.

CROP.	Disease.	Symptoms.	Control or prevention.
LETTUCE—*Concluded.*	Damping-off	Attacks many kinds of seedlings when very young.	Soil sterilization by steam or formaldehyde should be practiced. Care should be taken to avoid overwatering. Give sufficient ventilation. Apply flowers of sulphur or grape dust (*d*) liberally over the seedlings and soil.
MILLET	Kernel smut	The seed is replaced by "false kernels" of smut. The heads become darker brown.	Use the copper carbonate dust treatment same as for sorghum, or soak the seed in formaldehyde solution, 1 pint to 40 gallons of water for 1 hour.
OATS	Halo leaf blight	Small, light green, oval spots turning brown on leaves, followed by yellowing or reddening of leaf tips.	Generally not serious in Kansas. Treat seed oats as for smut before planting.
	Head blast	All or parts of the panicles are blasted and sterile.	Cause unknown. Environmental conditions are probably the chief agencies involved. Seed treatment of no value. Nothing can be recommended for its control.
	Leaf or crown rust	Small, yellowish pustules on plants. May cause very poor yield some bad seasons.	There is nothing that can be recommended. Only occasionally is it serious in Kansas.
	Smut	Panicles turn into black, sooty mass	The dry formaldehyde treatment, or the formaldehyde sprinkling method. The dry formaldehyde treatment should never be used for hull-less oats.
	Stem rust	Red and black pustules about $\frac{1}{8}$ inch long on stem.	Not generally common or troublesome in Kansas.
ONION	Smut	Black lesions of a dusty nature. Attacks bulbs or young stems.	Write for instructions how to use formaldehyde when planting seed. Not common in Kansas.
PEA	Root rot	Plants wilt and dry up	No remedy can be advised. Remove plants and burn. Plant peas in different part of the garden.

PLANT DISEASES AND THEIR CONTROL—CONTINUED.

CROP.	Disease.	Symptoms.	Control or prevention.
PEACH	Bacterial leaf spot or black spot.	Black spots on leaves which later crack and fall out, giving a shot-hole effect.	Good orchard culture, especially good soil fertility.
	Brown rot	Fruit turns brown and rots. Brown mold appears as fruit ripens. Cankers or sunken areas may appear on limbs, followed usually by gummosis.	Spray with lime-sulphur dormant spray. Dry-mix lime and sulphur when shucks have dropped. Repeat same spray as often as necessary to control disease. Control insects with arsenicals. (See spray schedule for stone fruits as advised in Station Circular 125.
	Crown gall	See apple diseases	See apple.
	Peach leaf curl	Leaves become thick, warp, curl, turn red, white and yellow. Twigs and fruit rarely attacked in Kansas.	The dormant lime-sulphur spray will control this disease.
	Scab	Small, yellowish spots on young twigs, and greenish-black spots on immature peaches.	Use the same spray schedule as recommended for brown rot of peach.
PEAR	Crown gall	See apple diseases	See apple.
	Fire blight	Twigs, leaves and blossoms turn brown and dry during season of rapid growth.	See apple. Write to the Agricultural Experiment Station for directions.
PEPPER	Anthracnose	Sweet and pungent varieties are susceptible. Small water-soaked spots on the fruit. These turn dark as they get older.	Spray with Bordeaux 3-6-50 at weekly intervals if the disease is bad.
	Fruit rot or black spot	Sunken dark spots on peppers. All sweet varieties are very susceptible.	It seems to be caused by sunburn. No control is effective.
PLUM	Blossom blight	The flowers dry up together with leaves which come from fruit spurs. This is a stage of brown rot.	Dormant spray. Keep trees free from mummied fruits. Apply sprays as for brown rot.
	Brown rot	Fruit decays and brown mould appears. May cause sunken cankers on limbs.	Spray trees when dormant with commercial lime-sulphur as for apples. When petals have fallen use dry-mix lime and sulphur followed by a third spray and subsequent sprays when fruit begins to ripen. Control insects with arsenicals. (See spray schedule for stone fruits as advised in Station Circular 125.

PLANT DISEASES AND THEIR CONTROL—CONTINUED.

CROP.	Disease.	Symptoms.	Control or prevention.
PLUM—*Concluded.*	Crown gall	See apple diseases	See apple.
	Plum knot	Black, rough, gall-like growth on young twigs. Especially severe on wild plums.	Prune out and *burn* all diseased limbs. Apply dormant spray and summer sprays as for brown rot if the disease is troublesome.
	Plum pockets	Fruit swells up to form bladders, three or four times the size of normal fruit.	Same sprays as for brown rot, but in addition give dormant spray as for peach-leaf curl.
POTATO	Black heart	Potatoes become black in the center of the tuber.	Potatoes stored without proper ventilation may become affected with blackheart. Especially severe at high temperatures.
	Blackleg	Plants die when 6 to 8 inches tall and later. The underground stem turns soft and black, leaves turn yellow.	Treat uncut seed by the corrosive sublimate treatment. See directions for seed potato treatment. Write the Agricultural Experiment Station for further information.
	Common scab	Rough, scabby spots on the skin of the potato. No other part of the plant attacked.	Somewhat worse where land has been heavily manured. Treat seed before planting as for Rhizoctonia. The scab organism lives indefinitely in most soils, therefore seed treatment and rotation will not necessarily control scab.
	Degeneration diseases	Such diseases as mosaic, spindle tuber, leaf roll, etc., belong to this group of diseases. Carried in the sap of the tuber and plant. They are a type of "running-out" of the stock.	Certified seed is more reliable and freer of these diseases than commercial seed.
	Dry rot	Infection occurs in field and develops rapidly in storage. White fungus causes tubers to dry and become "punky."	Sterilize bins or containers with 1 pint formaldehyde to 15 gallons water before storing potatoes Fall-treating seed, using the hot-formaldehyde method, seems to check its development somewhat. Less rot develops where storage temperature is kept between 34-38° F.
	Early blight (*e*)	Produces target-board-like spots, brown in color. Appears first on lowermost leaves. Spreads rapidly. Leaves dry up. Worst during wet weather in June.	Use Bordeaux 4-8-50. First spray when plants are 10 inches tall. Spray every week until plants are past the danger stage.

PLANT DISEASES AND THEIR CONTROL—CONTINUED.

CROP.	Disease.	Symptoms.	Control or prevention.
POTATO—*Concluded.*	Rhizoctonia or black scurf	Produce small black specks on tubers. Diseased sprouts have brown lesions on underground parts. Causes shoots to die.	Treat seed with corrosive sublimate or the hot formaldehyde treatments. See special directions for seed potato treatment.
	Soft rots	The potatoes become soft and watery in transit or storage.	Results from improper handling in the field, unnecessary bruising, exposure to sun and rain after sacking.
	Tip burn	The leaves turn brown and dry at the margins and tips of leaves. Curling of foliage is noticeable.	Spray with liquid Bordeaux 4-8-50, and arsenical as for blight.
	Wilt	Plants sometimes roll their leaves and wilt before they reach maturity. Tubers formed have black streaks in them.	Do not use seed showing black spots or streaks. This disease develops rapidly in storage. Do not advise storing Kansas-grown potatoes for winter use. Practice rotation.
SOY BEAN	Leaf blight	Small reddish-brown spots on leaves of young plants.	Generally not serious enough to stop growth. Affected plants soon recover. No method of control necessary.
SORGHUM	Head smut	Entire head is turned into smut mass. This is noticed as soon as it emerges from the "boot." Not very common in Kansas.	Seed treatment of little value. Crop rotation necessary. Red Amber sorgo is the most susceptible variety grown in Kansas.
	Kernel smut	The kernels are replaced by "false kernels," conical in shape and gray outside. When crushed between the fingers black smut is seen.	Use the copper-carbonate method as for stinking smut of wheat, or treat seed with formaldehyde treatment, 1 pint to 30 gallons of water for one-half hour.
	Sorghum blight	Reddish brown areas on leaves and stalks. Sometimes parts of the plant dry up.	No practical means of control. Generally not serious enough to cause very much damage.
SWEET POTATO (*f*)	Black rot	Blackened more or less circular sunken spots. When cut into they show dark olive-green color. Diseased potatoes have strong taste when cooked.	Select seed at digging time, using same suggestions given under "wilt." Plant clean seed (which has been treated) in new hotbeds and fields. Rotation should be practiced.
	Pox or pit	Small depressions or holes in the potato root, which becomes ill-shapen.	Treat seed as for black rot, crop rotations necessary.

PLANT DISEASES AND THEIR CONTROL—CONTINUED.

CROP.	Disease.	Symptoms.	Control or prevention.
SWEET POTATO (*f*)—*Concld.*	Soft rot and ring rot	These are very similar diseases occurring in storage. Potatoes become soft, giving off sweet odor. A white mouldy growth occurs.	Great care is necessary in handling sweet potatoes. Do not bruise them, especially at time of digging and storing. They should be stored in crates rather than bins. Regulate temperatures carefully.
	Stem rot or wilt	Young plants die when set out; old plants turn yellow, wilt more or less. Crown and runners when split open show brown discoloration inside.	Select seed at digging time in the field, not from the bin. Select only from good yielding hills with healthy vines. Plant disease-free plants in new soil. Sweet potatoes should be rotated for 5 to 7 years for best results.
RASPBERRY		See blackberry diseases.	
RYE AND CLOSELY RELATED GRASSES.	Ergot	Long, black, hard, horn-shaped fungous growth in place of seed.	Not very common in cultivated rye in Kansas. More common in rye grass and related species. Serious to cattle when eaten. Keep cattle away from pastures having ergot.
	Smut	Long, black ruptures in leaves and stems. Black dusty spore masses fill ruptures.	Not found in Kansas rye. The appearance of smut should be immediately reported.
STRAWBERRY	Black root	Plants are stunted and yellow. Roots turn black and decay. Diseased plants rarely produce runners.	Rotation for several years is necessary.
	Fruit rot in field	Fruit decays in field about the time it ripens or while still green.	Brought about by infection from the soil. Mulch crop with straw to keep berries from touching the ground.
	Leaf spot	Circular, brown spots, generally surrounded by purple color.	Generally not very serious on the strawberry crop in Kansas. No special control is usually necessary. Use Bordeaux when necessary.
	Slime moulds	In June, white jelly-like masses appear on the leaf and berry stems. Later this forms a light yellow, crusty mass. Other species appear as minute gray or white, scaly bodies on the under sides of the leaves.	These do not cause a disease nor do they cause any damage. Slime moulds are saprophytic plant growths commonly found in moist, shady locations.

PLANT DISEASES AND THEIR CONTROL—CONTINUED.

CROP.	Disease.	Symptoms.	Control or prevention.
TOMATO	Blossom drop	Plants grow thriftily but blossoms do not "stick."	Apply same fertilizer as for blossom-end rot.
	Blossom-end rot	Black, rotten spots appear on tomatoes, usually at blossom end, before the fruit is ripe.	No positive control or prevention is known. Keep plants staked, pruned, sprayed. It is advisable to irrigate when necessary. The water supply is probably the most important factor. Supply fertilizer (hard wood ashes) or commercial fertilizer high in potash when first blossoms appear.
	Fungous wilt	Bottom leaves begin to wilt, turn yellow and dry. Plant dies completely. Most noticeable in June and July. Root system becomes dried out from fungous infection.	Disease lives over in the soil for a number of years. Either rotate or grow resistant varieties. Write to the Agricultural Experiment Station for instruction.
	Leaf blight	Occurs on the lowermost leaves first, turning them yellow and causing them to dry. Gray spots with brown margin are present on leaves.	Where plants are trained and staked the disease is less prevalent. Spray with Bordeaux 4-5-50 when first bloom appears. Spray every week or 10 days until 3 to 5 applications are given. Keep horse nettle, perennial ground cherry, jimson weed and nightshade (weeds) away from tomato patch.
	Leaf mold	Olive-brown, felt-like mold occurs on the under side of leaves. Leaves turn yellow and gradually die.	Generally not serious in Kansas, but at times may destroy the crop in the greenhouse. Spray with Bordeaux 4-5-50 as soon as noticed. The under side of all new foliage must be covered. Unless the disease is checked early, it cannot be controlled.
	Mosaic or "fern leaf"	Leaves on plants become mottled (mosaic) yellow in the green leaf areas. Sometimes only part of the leaf develops making midribs pronounced.	Diseased plants do not produce much fruit. Keep out such weeds as horse nettle and perennial ground cherry because they harbor the disease.
	Nematode or eel-worm	Knots on the roots which eventually decay. Plants lack vigor and die prematurely. Caused by a microscopic worm.	Infestation carries over in the soil in greenhouse or out of doors. Soil sterilization necessary. A serious trouble. Write the Agricultural Experiment Station as soon as discovered.

CROP.	Disease.	Symptoms.	Control or prevention.
WATERMELON	Anthracnose or rind rot	Sunken, pinkish wet spots on rind of fruit. Causes the foliage to dry up suddenly in August or September.	Practice rotation. Treat seed in a 1 to 1000 mercuric chloride solution (see page 20). Destroy diseased fruit and vines, if possible. Use Bordeaux mixture 4-5-50. Spray when vines begin to run and 10 to 14 days thereafter until a week before harvest. Unless sprays are applied frequently the disease cannot be controlled.
	Blossom-end rot	The blossom end turns brown or black, becoming more or less soft.	Develops in the field and in transit. Practice crop rotation and using a stem-end disinfectant before shipping. Write to the Agricultural College for instructions. Never load melons showing the slightest indication of decay.
	Fusarium wilt	Plants begin to wilt after they have made a good growth and set fruit.	Treat seed before planting as for Anthracnose. The fungus lives over in the soil from 10 to 12 years. Burn diseased plants. No sprays effective. Crop rotation necessary.
	Ground rot	Where the side of the melon touches the soil decay may occur.	Not serious unless watermelons are grown too frequently on the same land. Rotate crops if this disease becomes prevalent. Never load melons showing decay.
WHEAT	Black chaff	Heads, beards, necks, culms and leaves become spotted with blotches of brown and black stripes.	Disease transmitted by infected seed and probably soil. Spreads by wind and rain. No seed treatment practical. No damage caused unless excessive rain occurs in June.
	Black stem rust	Black and red pustules on leaf, culms and heads, which vary in size from $\frac{1}{16}$ to $\frac{1}{8}$ inch in length, black stage ruptures epidermis, giving a sooty black appearance. Grain shrivels when plants are heavily infected.	No wheat grown in Kansas is entirely resistant. Kanred in the hard winter wheat belt is more resistant than any other hard winter wheat, and during the average season is not injured by black rust to any appreciable extent. It is not, however, immune from stem rust.
	Covered smut, stinking smut, bunt (common name for same disease).	Black smut masses or "smut balls" are found in place of seed. Has offensive or fetid odor.	Treat seed with the copper carbonate dust or formaldehyde treatments. See directions, page 17.

PLANT DISEASES AND THEIR CONTROL—CONCLUDED.

CROP.	Disease.	Symptoms.	Control or prevention.
WHEAT—*Concluded.*	Loose smut.....	Destroys glumes leaving naked stalk. Black mass is seen as heads emerge from the "boot."	Difficult to control. Secure special instructions from the Agricultural Experiment Station on how to use the modified hot water treatment in connection with a seed plot.
	"Red" or leaf rust....	Occurs mainly on the leaves but in severe cases, attacks the head and necks. May partially or completely kill plants in fall. Black stage does not rupture epidermis, giving glossy black appearance. Pustules much smaller than stem rust.	Ordinarily it does not cause shrunken grain. Not as serious as black rust. Kanred is generally resistant to leaf rust in Kansas. Other varieties are being developed which show resistance.
	Foot-rot or take-all.....	Several organisms cause plants to rot at the roots, destroying the root system. Heads do not fill. Little stooling takes place. This disease appears in definite spots in the fields or only on scattered plants. Lower internodes often show a blackened condition.	Should disease occur in field more than one season, crop rotation must be followed or land fallowed. Do not plant infested fields to wheat for 2 to 3 years. Use oats, corn, or forage crops in place of small grains.
	Scab	Portions of the heads turn "ripe" early. Pink mould often noticed on glumes. Grain may shrivel badly.	Use good plump seed that has been fanned and treated as for smut. Rotate crops but do not follow corn with wheat. Not a common or serious disease in Kansas.
	Septoria glume blotch	Black blotches on chaff; brown spots on leaves. Very small fungous spore cases (size of a pin point) occur on leaves and glumes.	Most prevalent during rainy seasons. No special treatment necessary.

(*a*) All sprays should be combined with insecticides to control insects. In these combination sprays, no spray containing soap should be combined with any containing lime. See insect control, Kansas Station Circular 125.
(*b*) A "pre-pink" spray applied just as the leaves are emerging from the buds is advisable and the most important in sections where apple scab is bad.
(*c*) Spray at frequent intervals, beginning as soon as plants appear above the ground.
(*d*) This is a compound manufactured by the Hammond Slug-Shot Company, Beacon, New York.
(*e*) All liquid Bordeaux sprays should be combined with arsenicals for insect control whenever necessary.
(*f*) Provide proper ventilation. Keep sweet potatoes at 80° to 90° F. during curing period. Regulate storage temperature 50° to 55° F. after curing.

SEED TREATMENTS

THE COPPER CARBONATE DUST METHOD

This dust treatment for sorghums, wheat, and millet is rapidly replacing the formaldehyde methods, since it is more rapid, there is less seed injury, and wheat, millet, or sorghum seed may be treated any time of year and stored. There are several makes of commercial machines for this purpose which are run by power and have a large capacity. A barrel smut-treating machine and a concrete mixer as described in Circular 107 of the Kansas Agricultural Experiment Station are satisfactory outfits for treating seed for small acreages. The type of outfit to be used should be determined by the amount and kind of seed to be treated. Any standard brand of copper carbonate may be used for the control of stinking smut of wheat, millet smut, and the kernel smut of sorghum. *The copper carbonate dust treatment is not recommended for any of the other smut diseases of cereals. Those grades of copper carbonate analyzing from 50 to 55 per cent copper content require two ounces to the bushel of grain and are considered the best, while those with a lower copper content should be used at the rate of three to four ounces.*

It should be emphasized, if seed is black with smut, i. e., if the brush end of the wheat kernel is black, such seed should not be used for planting, or if it is to be used it must be fanned and given the formaldehyde treatment. Complete smut control is not obtained with copper carbonate when such seed is treated. Always use fanned seed no matter what the fungicidal treatment is.

It is very important that one know about the copper content of the brand he is using and the fineness of the dust. At least 90 per cent of the dust should pass through a 200-mesh screen, since the fineness seems to be as important as the copper content. The seed and dust are mixed together in one of the treating outfits and mixed at least from a minute and a half to two minutes, so as to get the seed thoroughly covered with dust. This can be done only by using one of the outfits described. *One should not attempt to shovel the seed and dust together in a watering trough, grain drill, or wagon box, since this will result in disappointment.* Do not inhale the copper carbonate dust, since it causes nausea and irritates the mucous membranes of the nose and mouth.

Treated grain, while not exactly poisonous to stock, causes digestive disorders and other disturbances and it is not safe to feed treated grain. No troubles have been reported as a result of chickens

eating treated seed, but it is not advisable to feed it in large quantities. *In no case should copper carbonate treated seed be mixed with other wheat and sold for milling purposes. Disastrous results may result if flour is used which has been made from wheat treated with copper carbonate.* Send for complete instructions on the copper carbonate dust method.

FORMALDEHYDE SEED TREATMENTS FOR GRAIN

Dry or Mist Method

The Formaldehyde (Formalin) Treatment.—This treatment is used either in the so-called "dry" method, or in dilute solutions for wetting the grain. *The dry or mist method is recommended only for oats and not other grains since it may cause serious injury. The dry or formaldehyde-mist method must never be used for hull-less oats or millet seed, since it will almost completely kill the seed.* Where oats is to be treated for smut, one pint of full-strength formaldehyde is mixed with one pint of water and placed in a small quart hand sprayer. The one quart of solution is sufficient for treating 50 bushels of oats. One stroke of the piston gives enough mist for a common dirt shovelful of seed. Scoop shovels require about 4 strokes. Throw treated grain in a pile and cover with sacks, cloth, or blankets for 5 hours or over night. It is then ready for planting.

Sprinkling Method

The sprinkling method may be used for wheat if the seed has been fanned. It may also be used for oats. Mix 1 pint of formaldehyde with 40 gallons of water. Sprinkle this on the grain that has been spread out in thin layers. Shovel over several times during the sprinkling so as to wet the grain thoroughly. Shovel into a pile and leave covered for 5 hours, or over night for wheat and oats. This amount of solution is sufficient to treat about 40 bushels of grain.

Long-Time Formaldehyde Treatment

This is recommended only for barley smut control. It is not extensively used, but has given very satisfactory control for the covered barley smut and frequently gives complete control of the loose smut of barley (see also Uspulun and Semesan treatments for barley smuts). The long-time formaldehyde treatment consists of soaking barley seed which is in sacks in a solution of 1 pint of full-strength formaldehyde and 40 gallons of water. Allow the seed to soak 2 hours after which the sacks are removed and the seed spread out to dry sufficiently so that it will run through the drill.

Formaldehyde Soaking Method

The soaking method for sorghum seed consists of making a solution of 1 pint of formaldehyde with 30 gallons of water and soaking the grain for one-half hour, after which it is dried and ready for planting. If the seed is badly smutted it must be dumped into the treating solution and the refuse skimmed so as to remove the smut masses. The seed should be stirred so that all the refuse will come to the surface.

Precautions in Using Formaldehyde

1. Always see that it is guaranteed full strength, *i. e.*, 37 to 40 per cent.
2. Do not use more or less formaldehyde than the directions call for.
3. Plant all grain which has been treated as soon as possible after treatment. Do not store it after treatment as seed injury results.
4. Seed does not have to be dry before planting. Plant as soon as it will pass through the drill.
5. Do not plant treated seed in dry ground.

HOT FORMALDEHYDE TREATMENT FOR SEED POTATOES

This treatment consists of mixing 2 pints of full-strength formaldehyde in 30 gallons of water. Metal containers may be used, since this solution does not corrode metal. The temperature of this solution should be kept from 124° to 126° F. and the seed treated for 3 minutes. Seed potatoes may be treated in sacks, which simplifies the seed treatment process. Seed potatoes should be treated before cutting. *Accurate mercury thermometers should be used in preference to spirit thermometers, since they are generally more accurate.* This treatment is more rapid, just as effective in controlling seed-borne diseases, and no more expensive than the corrosive sublimate treatment. The cost per acre will range close to one dollar. The solution may be heated by steam if steam under pressure is available at creameries, or from a stationary boiler. In some cases open fires underneath the tank have been used with success. Wood or coal may be used. Several galvanized iron treating outfits with oil burners are on the market. For complete directions send for the hot formaldehyde seed treatment circular.

USPULUN AND SEMESAN SEED TREATMENTS

Uspulun and Semesan are chemical compounds that have fungicidal properties. Uspulun is used in a solution, while Semesan may be used either as a solution or a dust. Since these substances are much more expensive than formaldehyde or copper carbonate, their use must be limited. Both Uspulun and Semesan are satisfactory for barley smut control. They have some advantages over other known treatments. *Since these substances are poisonous, treated grain must never be fed to animals.* The treatment consists of soaking the seed in a 0.25 to 0.3 per cent solution for 1 to 1½ hours. The solution weakens rapidly, therefore it must be replaced by a new one after it has been used for 2 dips. Write the Agricultural Experiment Station for further directions.

CORROSIVE SUBLIMATE TREATMENT

White Potatoes.—The corrosive sublimate treatment of white potatoes is a satisfactory method to use, especially where small acreages of potatoes are planted. Prepare a solution by mixing 4 ounces of corrosive sublimate in 30 gallons of water. Place corrosive sublimate in several quarts of warm water. *Never use metal containers of any kind since this chemical corrodes metal and weakens the solution.* If an equal amount of sal ammoniac or table salt is added the corrosive sublimate goes into solution more rapidly. *This solution is extremely poisonous when taken internally, but will not injure the hands.* Place the uncut tubers in crates (never in sacks) and submerge in the solution for 1½ hours. Remove tubers and cut. Use a fresh solution after every third batch of seed treated, since the solution loses its strength rapidly. *Keep solution away from children and stock.* Send for special circulars on potato seed treatment.

Sweet Potatoes.—Dissolve 4 ounces of corrosive sublimate in 32 gallons of water, as described for the white potato seed treatment. Place potatoes in crates and dip for 10 minutes only, then allow to dry. Make up new solution as for white potatoes, as it loses its strength rapidly. Send for special circulars on sweet-potato diseases.

Watermelons, Cucumbers, Cantaloupes.—Treat the seed in a solution made by mixing one tablet of corrosive sublimate in a quart of warm water, using a crock or glass container. Place the seed in a cloth sack and allow the seed to soak in the solution (after it is cool) for 10 minutes, but not longer. Wash seed thoroughly in water before planting.

SEED TREATMENT FOR CABBAGE SEED

It is well to disinfect cabbage seed before planting on account of black rot. It has been found that steeping the seed in hot water at 122° F. for ½ hour is a satisfactory method. Extreme care should be taken to keep this temperature. A high-grade thermometer is necessary. It is best to place the seed in a cheesecloth bag so that the water can circulate freely.

SPRAYS AND OTHER MIXTURES [2]

BORDEAUX MIXTURE

This spray is composed of copper sulphate (bluestone), hydrated lime, and water. The formula 4-5-50 means that it consists of 4 pounds of copper sulphate, 5 pounds of hydrated lime, in 50 gallons of water. Sometimes the 2-3-50 or 3-4-50 formulas are recommended for certain plant diseases in place of the 4-5-50 strength, but it should be remembered that the first figure stands for the copper sulphate, the second for hydrated lime, and the third for the quantity of water. The composition of 4-5-50 Bordeaux mixture is indicated by the following:

Copper sulphate (bluestone)	4 pounds.
Hydrated lime of good quality	5 pounds.
Water	50 gallons.

Any quantity of spray can be made that is desired. If 25 gallons are needed, divide the above quantities by 2; if 12½ gallons are wanted, divide by 4; if 100 gallons are desired, multiply by 2; etc.

Dissolve the copper sulphate by suspending it in a gunny sack near the surface in a few gallons of water. Use only wooden or earthen vessels and do not allow metal to come in contact with the solution for it "eats" through iron, tin, and similar metals. If warm water is used, the dissolving of the copper sulphate will be hastened.

Hydrated lime (not air slacked) that is fresh and of good quality is most commonly used in place of stone lime, but it is necessary to use from ⅓ to ½ more by weight. Hydrated lime can be generally secured more readily in small quantities and for this reason it is more practical to use.

After the copper sulphate is dissolved, add enough water to the copper sulphate solution to make 25 gallons. Do the same with the milk of lime solution, adding enough water to make 25 gallons.

2. For a detailed discussion of this subject the reader is referred to Circular 125 of the Agricultural Experiment Station.

Pour these two dilute solutions together into the spray tank. Where small sprayers are used, take equal amounts of these solutions, placing the lime solution in the tank and adding the copper sulphate solution to it. Strain out all coarse materials in order to prevent clogging the spray nozzles. The resulting mixture should be sky blue in color.

This spray should be used immediately, observing carefully the practices found necessary to insure a proper application of Bordeaux mixture.

Although Bordeaux mixture is one of the most efficient fungicides known, it has limitations in its application. It is not safe to use during damp or rainy weather because severe injury to the foliage may result.

Stock Solutions.—Sometimes it is more convenient to make what is known as "stock solutions." This saves frequent dissolving and mixing of chemicals. To make a stock solution, dissolve 1 pound of copper sulphate in every gallon of water used. Slake 1 pound of stone lime for every gallon of water used. Keep in separate containers and be careful to prevent evaporation. Use these stock solutions when making Bordeaux mixture. If it is desired to make a 4-5-50 Bordeaux mixture, take 4 gallons of the copper sulphate stock, add 21 gallons of water, and place in one container. Use 5 gallons of lime stock, place in a separate container, and add 20 gallons of water, stirring it thoroughly so as to have all lime in suspension. The two liquids are then ready to be combined as before mentioned.

COMMERCIAL LIME SULPHUR

This is one of the commonest fungicides used in the orchard and for some of the small fruits. It is generally purchased from chemical supply houses although it is still made by a few fruit growers who own large orchards. This spray when used at the proper dilution is a valuable fungicide and may be used when it is not safe to apply Bordeaux mixture. Directions for diluting are generally specified when control measures call for the use of commercial lime sulphur.

DRY-MIX LIME AND SULPHUR

Recently a new spray has been developed known as the dry-mix lime and sulphur spray. This is recommended for peaches and plums and has been used with satisfaction by this Agricultural Ex-

periment Station. The directions for making 50 gallons of the spray are as follows:

Flowers of sulphur	8 pounds.
Fresh hydrated lime	4 pounds.
Calcium caseinate or kayso	½ pound.

If only a small amount of this spray is desired, the amounts may be decreased accordingly. Mix the ingredients together in their dry state and sift the mixture so that all lumps are removed. Make a thin paste by adding water. This should be added to about 25 gallons of water in the spray tank and stirred thoroughly, after which the rest of the water (25 gallons) should be added. This will give the entire 50 gallons of spray liquid. It is advisable to use this spray immediately. Insecticides may be added if necessary.

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